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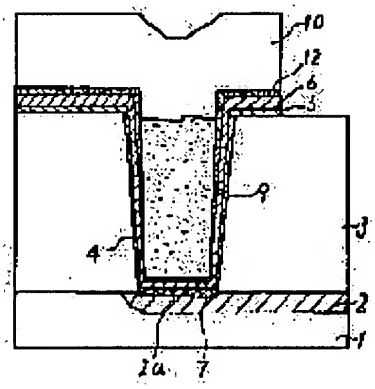
(54) SEMICONDUCTOR DEVICE AND MANUFACTURE THEREOF

(57)Abstract:

PURPOSE: To manufacture a barrier layer between a first conductor and a second conductor in a short time at low costs.



CONSTITUTION: A first titanium layer 5 is formed by sputtering titanium on a layer insulating layer 3 and a contact layer 2a in the atmosphere of argon gas by using a collimation sputtering device, a titanium nitride layer 6 is formed by applying the reactive sputtering of titanium to the first titanium layer 5 in the atmosphere of nitric property and a second titanium layer is formed by sputtering titanium on the titanium nitride layer 6 in the atmosphere of argon gas, sequentially. After that, heat treatment is performed in the atmosphere of nitric property, the contact part between the first titanium layer 5 and the contact region 2a is made into a titanium silicide layer 7 and the second titaniu layer is made into thermal titanium nitride layer. A tungsten layer is formed in the surface of the thermal titanium nitride layer and a tungsten plug 9 is formed in the contact region 2a by

etching back An aluminum layer is formed in the surfaces of exposed thermal titanium nitride layer and the plug 9 and a wiring part 10 is formed by etching.

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* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the structure and its manufacture approach of a connection with the 2nd conductor especially connected electrically through the contact field of the 1st conductor, and the contact hole of a layer insulation layer with respect to a semiconductor device and its manufacture approach.
[0002]
[Description of the Prior Art] The contact hole of a layer insulation layer prepared in order to carry out electrical installation between the contact hole of a layer insulation layer prepared in order to carry out electrical installation with the impurity diffusion field formed in the front face of a semi-conductor substrate, for example, the source / drain field of an MOS transistor, and a wiring layer with detailed-izing of a semiconductor device in recent years, and an up-and-down wiring layer has also been made detailed. Since the aspect ratio (ratio of height to the diameter of opening of a contact hole) of a contact hole becomes large with detailed-izing of these contact holes, metal plugs, such as a tungsten, are embedded in a contact hole, and it can be possible to perform electrical installation of the impurity diffusion field and wiring layer which were formed in the front face of a semi-conductor substrate through this metal plug, or electrical installation between up-and-down wiring layers.
[0003] Thus, the manufacture approach is explained according to drawing 11 thru/or drawing 15 about the semiconductor device which performed electrical installation of the impurity diffusion field and wiring layer which were formed in the front face of a semi-conductor substrate through the metal plug. First, as shown in drawing 11 , the layer insulation layer 3 is formed on the front face of the semi-conductor substrate 1 which consists of a silicon substrate by which the impurity diffusion field 2 where a part becomes contact field 2a was formed in the front face, and a contact hole 4 is formed so that contact field 2a may be exposed in this layer insulation layer 3.
[0004] Next, as shown in drawing 12 , a spatter is first performed in an argon gas ambient atmosphere using the sputtering system equipped with the titanium target, and the titanium layer 5 is formed on contact field 2a located on the whole front-face top surface of the semi-conductor substrate 1, i.e., the front face of the layer insulation layer 3, and in the contact hole 4 of the layer insulation layer 3. And using the sputtering system equipped with the titanium target, a spatter (reactant spatter) is performed in the nitriding nature ambient atmospheres in nitrogen-gas-atmosphere mind or the mixed-gas ambient atmosphere of nitrogen and an argon etc., and the titanium nitride layer 6 is formed all over the whole front-face top surface of the semi-conductor substrate 1, i.e., the front face of the titanium layer 5.
[0005] Then, as shown in drawing 13 , it heat-treats and let the contact section with contact field 2a in the titanium layer 5 be the titanium silicide layer 7. All the titanium layers of the contact section with contact field 2a in the titanium layer 5 were silicide-ized, and this titanium silicide layer 7 has entered the interior of the impurity diffusion field 2 somewhat. Thus, the thing of the two-layer structure which consists of a formed titanium layer 5 which has the titanium silicide layer 7, and a titanium nitride layer 6 becomes a barrier metal layer eventually.

[0006] Next, all over the whole front-face top surface of the semi-conductor substrate 1, i.e., the front face of the titanium nitride layer 6, as shown in drawing 14 , the tungsten layer 8 is formed with the blanket CVD method which used WF6 gas. Etchback of the whole surface of this tungsten layer 8 is carried out, only in contact field 2a, it leaves a tungsten layer and the tungsten plug 9 is formed. And as shown in drawing 15 , an aluminum layer is formed in the whole front-face top surface of the semi-conductor substrate 1, i.e., the whole surface surface of the exposed titanium nitride layer 6, and the front face of the tungsten plug 9, this aluminum layer is etched with the usual photoengraving-process technique, and the wiring section 10 is formed.
[0007] At this time, the titanium layer 5 located under an aluminum layer and the titanium nitride layer 6 are also etched and removed except for the part located under the wiring section 10. In addition, the wiring section 10 constitutes the wiring layer by the tungsten plug 9. Thus, the wiring layer which consists of the impurity diffusion field 2, the wiring section 10, and the tungsten plug 9 which were formed in the front face of the semi-conductor substrate 1 will be electrically connected through the barrier metal layer which consists of a titanium silicide layer 7 and a titanium nitride layer 6.
[0008] thus -- since the titanium layer 5 which has the titanium silicide layer 7 returns the natural-oxidation film which exists on contact field 2a on the occasion of heat treatment of the titanium layer 5 since titanium is activity, and reacts with the silicon of the impurity-diffusion field 2 in the constituted semiconductor device and the titanium silicide layer 7 is formed -- low [of the impurity-diffusion field 2 and a wiring layer] -- the role which realizes electrical installation [****] has played.
[0009] Since film exfoliation is produced, or WF6 and the titanium layer 5 which are material gas for forming the tungsten layer 8 will react and formation of the tungsten layer 8 will become difficult if it forms in the front face of the direct titanium layer 5 in case the tungsten plug 9 which constitutes a wiring layer is formed, the titanium nitride layer 6 functions as an adhesion layer of the titanium layer 5 and the tungsten layer 8. Moreover, in case this titanium nitride layer 6 forms the tungsten layer 8 with the blanket CVD method which used WF6 gas, it has played the role which prevents that a wormhole occurs to the impurity diffusion field 2. Poor junction will be caused, if this wormhole points out the tungsten of the shape of a mustache prolonged into the semi-conductor substrate 1 from impurity diffusion field 2 front face generated by the reaction of WF6 gas for forming the tungsten layer 8, and the silicon of the impurity diffusion field 2 and this wormhole grows to the interface of the impurity diffusion field 2 and the semi-conductor substrate 1, i.e., near a PN-junction side.
[0010] Thus, the following troubles were encountered, as a result of this invention person's etc. advancing detailed-ization further based on the constituted semiconductor device and examining many things. Namely, the place which advanced detailed-ization one by one and manufactured various semiconductor devices, If the aspect ratio of the contact hole 4 of the layer insulation layer 3 becomes high according to detailed-izing and an aspect ratio becomes 2.5 (it is 0.6 micrometers or less when it says for the diameter of a contact hole 4) or more The thickness of contact hole 4 pars basilaris ossis occipitalis 5, i.e., the titanium film formed on contact field 2a of the impurity diffusion field 2, and the titanium nitride film 6 becomes very thin. low [of the tungsten plug 9 and the impurity diffusion field 2 which constitute a wiring layer] -- while connection [****] became difficult, as drawing 14 and drawing 15 showed to a sign 11, the wormhole occurred.
[0011] Thus, bottom product coverage (ratio of the thickness located in contact hole 4 pars basilaris ossis occipitalis to the thickness located in a flat part) worsens as a dotted line A shows to drawing 17 and the aspect ratio of a contact hole 4 becomes high, and the aspect ratio of a contact hole 4 depends [bottom product coverage] on becoming it below 0.05 (5%) that the thickness of the titanium film 5 formed in contact hole 4 pars basilaris ossis occipitalis and the titanium nitride film 6 becomes very thin in 2.5.
[0012] The aspect ratio whose depth the diameter of a contact hole 4 is 0.5 micrometers, and is 1.5 micrometers specifically sets to the thing of 3. The place in which the titanium layer 5 whose thickness is about 200A, and the titanium nitride layer 6 whose thickness is about 1000A were formed on the front face of the layer insulation layer 3, i.e., a flat part, The thickness of the titanium film 5 formed in contact hole 4 pars basilaris ossis occipitalis and the titanium nitride film 6, respectively 4A, low [of the

tungsten plug 9 and the impurity diffusion field 2 which are dramatically as thin as about (bottom product coverage is about 2%) 20A, and constitute a wiring layer] -- connection [****] is difficult and, moreover, the wormhole 11 as shown by drawing 14 and drawing 15 occurred.

[0013] On the occasion of formation of these titanium film 5 and the titanium nitride film 6, using the collimation spatter method for "Proc. VMIC Comferrence, P.P.253-259 "COLLIMATED SPUTTERINGOF TiN/Ti LINES INTO SUB-HALF MICRONHIGH ASPECT RATIO CONTACT/LINES"" is proposed as an approach of raising bottom product coverage.

[0014] Then, using the collimation spatter equipment shown in drawing 16 , the artificer etc. manufactured various semiconductor devices and examined many things. In drawing 16 , 100 is a body of equipment, the interior is made into argon atmosphere at the time of titanium layer 5 formation, and the interior is made into the mixed-gas ambient atmosphere of nitrogen and an argon at the time of titanium nitride layer 6 formation. The wafer 102 with which 101 is the heating stage with which the interior of this body of equipment was equipped, and two or more semiconductor devices are formed in that top face is laid. The titanium target with which 104 was prepared above the heating stage 102 in the body of equipment 101 interior, and 105 are the collimators formed between the heating stage 101 and the titanium target 104, and even the wafer for 103 to fix this wafer 102 to the heating stage 101 has the board with which two or more holes were formed in the shape of a blow hole of a bee. 106 is shielding prepared in the body of equipment 101 interior so that even a part of heating stage 101 and a wafer might enclose 103, the titanium target 104, and a collimator 105.

[0015] Thus, in order to form the titanium layer 5 using the constituted collimation spatter equipment, the wafer 102 containing the semiconductor device formed to the condition shown in drawing 11 is laid on the front face of the heating stage 101, and even a wafer is fixed in 103. A wafer 102 is heated by the heating stage 102. On the other hand, argon gas is poured in into the body 101 of equipment, and the body of equipment 101 interior is made into an argon gas ambient atmosphere. And power is supplied to the titanium target 104. Then, the sputtered particles of titanium are emitted from the titanium target 104, many slanting components will be removed by the collimator 105, the emitted sputtered particles will come flying on a wafer 102, and the titanium layer 5 will be formed on the front face of the layer insulation layer 3 on contact field 2a of the impurity diffusion field 2 in which the contact hole 4 of the layer insulation layer 3 is located, and the side face of the contact hole 4 of the layer insulation layer 3.

[0016] Moreover, in order to form the titanium nitride layer 6, where the titanium layer 5 is formed, the power of the titanium target 104 is turned off, nitrogen gas is poured in into the body 101 of equipment at impregnation and coincidence of argon gas, and the body of equipment 101 interior is made into the mixed-gas ambient atmosphere of argon gas and nitrogen gas. And power is supplied to the titanium target 104. Then, the sputtered particles of titanium are emitted, and it reacts with the nitrogen in a mixed-gas ambient atmosphere, and becomes the sputtered particles of titanium nitride from the titanium target 104. As for these sputtered particles, many slanting components will be removed by the collimator 105, it will come flying on a wafer 102, and the titanium nitride layer 5 will be formed on the whole surface surface of the titanium layer 5.

[0017] Thus, when the titanium layer 5 and the titanium nitride layer 6 which are formed were formed on condition that versatility, the relation which shows the bottom product coverage to the aspect ratio of a contact hole 4 to drawing 17 was obtained. In drawing 17 , bottom product coverage [as opposed to / continuous line / B / the aspect ratio of the contact hole 4 in case the aspect ratio of a collimator 105 is / 0.5 and a continuous line C / for the aspect ratio of a collimator 105 / the aspect ratio of a collimator 105 of 1.5 and a continuous line E / 2.0 as for 1.0 and a continuous line D in the aspect ratio (ratio of height to the diameter of the hole formed in the collimator 105) of a collimator 105] is shown.

[0018] Bottom product coverage is improved to the thing in which the titanium layer 5 and the titanium nitride layer 6 were formed, in the spatter for which what formed the titanium layer 5 and the titanium nitride layer 6 using the collimation spatter method does not use a collimator so that clearly from this drawing 17 . For example, if the aspect ratio of a collimator 105 is one of the things (the height of 2cm and a hole is 3cm for the diameter of a hole) of 1.0, the improvement of about 4-time bottom product coverage is carried out.

[0019]
[Problem(s) to be Solved by the Invention] However, if it was in some which did in this way and formed the titanium layer 5 and the titanium nitride layer 6, the following problems arose. Compared with that to which the film formation rate of the titanium layer 5 and the titanium nitride layer 6 does not use the collimation spatter method for the 1st, it falls substantially, and the throughput of collimation spatter equipment decreases. For example, when the aspect ratio of a collimator 105 used the thing (the height of 2cm and a hole is 3cm for the diameter of a hole) of 1.0, the formation rate fell to 1 / 4 - 1/5. That is, since many slanting components of the sputtered particles from the titanium target 104 are removed by the collimator 105, it originates in the sputtered particles which fly to a wafer 102 decreasing.
[0020] The titanium nitride adhering to a collimator 105 exfoliates at the time of film formation of the titanium layer 5 and the titanium nitride layer 6, falls on a wafer 102, and serves as [2nd] a source of release of particle 108. That is, since processing hundreds of wafers 102 with one collimator 105 is called for, a collimator 105 will adhere to the titanium and titanium nitride dozens of micrometers or more of thickness. Since titanium nitride is chemically stable, since stress is large, it is [the adhesion force with a substrate] comparatively weak that it is easy to produce exfoliation the cause. In addition, although stress acts as a paste small, since titanium has few amounts of spatters of the titanium to titanium nitride, it cannot control exfoliation of titanium nitride so much. For example, when the aspect ratio of a collimator 105 used the thing (the height of 2cm and a hole is 3cm for the diameter of a hole) of 1.0 and dozens of wafers 102 were processed, particle 108 increased several or more times.
[0021] Time amount, i.e., time amount until it will be in the condition that the sputtered particles of the titanium from the titanium target 104 can be emitted, until the length of a vacuum performed before forming the titanium layer 5 in a wafer 102 worsens and it forms [3rd] the titanium layer 5 as a wafer 102 is processed becomes long. That is, when the titanium nitrides to which a collimator 105 adheres increase in number, it originates in the nitrogen gas emitted from the adhering titanium nitride increasing.
[0022] As one method of solving the 2nd and 3rd above-mentioned problems, as shown in drawing 16 , it is possible to establish the so-called cleaning period which makes the sputtered particles of titanium emit to it from the titanium target 104 where a shutter 108 is closed after installing a shutter 109 between a collimator 105 and a wafer 102 and forming the titanium nitride layer 6 in collimation spatter equipment.
[0023] That is, since titanium is activity and it acts as a paste, exfoliation of the titanium nitride to which the collimator 105 adhered is controlled, and generating of particle is controlled. And since titanium covers the titanium nitride to which the collimator 105 adhered and it adheres to it, while controlling bleedoff of the nitrogen gas from the titanium nitride to which it adhered, the titanium itself to which it adheres adsorbs nitrogen gas, an exhaust air operation is carried out, and the time amount which vacuum suction takes is not worsened. For these reasons, the 2nd and 3rd above-mentioned problems are improvable.
[0024] Next, based on such an idea, a concrete example in which the titanium layer 5 and the titanium nitride layer 6 which were shown in drawing 12 using collimation spatter equipment with a shutter 109 were formed is explained according to drawing 18 . Specifically, the aspect ratio of a collimator 105 forms the titanium layer 5 whose thickness the aspect ratio whose depth the diameter of a contact hole 4 is 0.5 micrometers, and is 1.5 micrometers is about 200A on the front face of the layer insulation layer 3, i.e., a flat part, in the thing of 3, and the titanium nitride layer 6 whose thickness is about 700A using the thing (for the diameter of a hole, the height of 2cm and a hole is 3cm) of 1.0.
[0025] First, the wafer 102 containing the semiconductor device formed to the condition shown in drawing 11 is laid on the front face of the heating stage 101, and even a wafer is fixed in 103. A wafer 102 is heated by the heating stage 102. Moreover, vacuum suction of the body of equipment 101 interior is carried out. In this condition, argon gas is introduced in the body 101 of equipment, and the body of equipment 101 interior is made into an argon gas ambient atmosphere. And power is supplied to the titanium target 104 in the condition which the shutter 109 opened, i.e., the condition that a shutter 109 does not exist between the titanium target 104 and a wafer 102. In addition, it takes for 15 seconds as

time amount until the flow rate of the argon gas to the body of equipment 101 interior is stabilized as time amount (argon gas installation period) after argon gas is introduced until power is supplied to the titanium target 104, and the period and argon gas which power is supplied to the titanium target 104 and form the titanium layer 5 are continuing being introduced.

[0026] Then, the sputtered particles of titanium are emitted from the titanium target 104, many slanting components will be removed by the collimator 105, the emitted sputtered particles will come flying on a wafer 102, and the titanium layer 5 will be formed on the front face of the layer insulation layer 3 on contact field 2a of the impurity diffusion field 2 in which the contact hole 4 of the layer insulation layer 3 is located, and the side face of the contact hole 4 of the layer insulation layer 3. When the formation period of this titanium layer 5 was performed for 30 seconds, the titanium layer 5 whose thickness is about 200A was obtained on the front face of the layer insulation layer 3, i.e., a flat part, and the titanium layer 5 whose thickness is about 30A was obtained on contact field 2a of the impurity diffusion field 2 in which the contact hole 4 of the layer insulation layer 3 is located (bottom product coverage is about 15%).

[0027] Next, in the condition of having described above, the power of the titanium target 104 is turned off, nitrogen gas is poured in into the body 101 of equipment at impregnation and coincidence of argon gas, and the body of equipment 101 interior is made into the mixed-gas ambient atmosphere of argon gas and nitrogen gas. And power is supplied to the titanium target 104. In addition, it takes for 15 seconds as time amount until the flow rate of the nitrogen gas to the body of equipment 101 interior is stabilized as time amount (nitrogen gas installation period) after nitrogen gas is introduced until power is supplied to the titanium target 104, and the period and argon gas which power is supplied to the titanium target 104 and form the titanium nitride layer 6, and nitrogen gas are continuing being introduced.

[0028] Then, the sputtered particles of titanium are emitted, and it reacts with the nitrogen in a mixed-gas ambient atmosphere, and becomes the sputtered particles of titanium nitride from the titanium target 104. As for these sputtered particles, many slanting components will be removed by the collimator 105, it will come flying on a wafer 102, and the titanium nitride layer 5 will be formed on the whole surface surface of the titanium layer 5. When the formation period of this titanium nitride layer 5 was performed for 105 seconds, the titanium nitride layer 6 whose thickness is about 700A was obtained on the front face of the layer insulation layer 3, i.e., a flat part, and the titanium layer 5 whose thickness is about 105A was obtained on contact field 2a of the impurity diffusion field 2 in which the contact hole 4 of the layer insulation layer 3 is located (bottom product coverage is about 15%).

[0029] Next, the power of the titanium target 105 is turned off and a shutter 109 is made for a shutter 109 to exist between closing 104, i.e., a titanium target, and a wafer 102. Installation of nitrogen gas is also suspended at this period. It required for 15 seconds as a period which closes this shutter. After the shutter 109 has closed, power is supplied to the titanium target 105 and the sputtered particles of titanium are made to emit from the titanium target 104. While the emitted sputtered particles adhere to a collimator 105, the sputtered particles of titanium which passed the collimator 105 adhere to a shutter 109.

[0030] Consequently, exfoliation of the titanium nitride to which titanium acted on as a paste and the collimator 105 adhered is controlled, and moreover, titanium covers the titanium nitride to which the collimator 105 adhered, and it adheres to it. The period (cleaning period) which carries out the spatter of this titanium acted as a paste, and required titanium nitride for 30 seconds as time amount required for that of a wrap. Then, installation of closing and simultaneous argon gas is suspended for a shutter 109 (it required for 10 seconds as this period), and a series of processings of formation of the titanium layer 5 and the titanium nitride layer 6 are ended.

[0031] When it forms to the condition it is similarly indicated to drawing 15 that described above the thing with the titanium layer 5 and the titanium nitride layer 6 which were formed, thus, about 500 wafers 102 The titanium silicide layer 7 formed of heat treatment The role which realizes electrical installation [****] is played. that the thickness of whose is about 75A obtains -- having -- low [of the impurity diffusion field 2 and a wiring layer] -- Moreover, the titanium nitride layer 6 prevents the film exfoliation at the time of forming the tungsten plug 9 which constitutes a wiring layer, and functions as

an adhesion layer of the titanium layer 5 and the tungsten layer 8. The thickness on contact field 2a of the impurity diffusion field 2 in which the contact hole 4 of the layer insulation layer 3 is located about 105A A ****, When forming the tungsten layer 8 with the blanket CVD method using WF6 gas, the role which prevents that a wormhole occurs to the impurity diffusion field 2 was played.
[0032] However, since the period (cleaning period) which closes a shutter 109 and carries out the spatter of the titanium from the titanium target 104 cannot perform film formation of a up to [a wafer 102] using this equipment when the titanium layer 5 and the titanium nitride layer 6 are formed using collimation spatter equipment with a shutter 109 as mentioned above, the throughput of collimation spatter equipment declines. Moreover, since the spatter of the titanium is carried out also to the cleaning period from the titanium target 104, the increment in the consumption of titanium is caused.
[0033] Furthermore, since it adheres to titanium also at a cleaning period, and it also becomes early that the path of a hole becomes small and an effectual aspect ratio increases and it also becomes early that the sputtered particles which come flying on a wafer 102 decrease, a collimator 105 will need to speed up the exchange stage of a collimator. In short, the increase in cost for formation of the barrier layer which consists of the lowering, the titanium layer 5, and titanium nitride layer of a throughput of collimation spatter equipment was what is not avoided.
[0034] This invention is made in view of the above-mentioned point, and electrical installation with the 2nd conductor electrically connected to the 1st contact field and this contact field of a conductor through the contact hole of a layer insulation layer aims at acquiring the semiconductor device which can be performed by low resistance, and its manufacture approach. The 2nd object of this invention is acquiring the semiconductor device which can prevent a wormhole occurring in the 1st conductor on the occasion of formation of the 2nd conductor, and its manufacture approach.
[0035] The 3rd object of this invention is acquiring the semiconductor device which is short time amount and can form cheaply the barrier layer prepared between the 2nd conductor electrically connected to the 1st contact field and this contact field of a conductor in the contact hole of a layer insulation layer, and its manufacture approach. The 4th object of this invention is acquiring the semiconductor device which can suppress and form generating of particle on the occasion of formation of the barrier layer prepared between the 2nd conductor electrically connected to the 1st contact field and this contact field of a conductor in the contact hole of a layer insulation layer, and its manufacture approach.
[0036]
[Means for Solving the Problem] The semiconductor device concerning invention of the 1st of this invention The layer insulation layer by which it was formed on the 1st conductor which has a contact field on a front face, and this 1st conductor, and the contact hole was formed on the contact field of the 1st conductor, The titanium silicide layer formed on the contact field of the 1st conductor located in the contact hole of this layer insulation layer, the titanium nitride layer formed by the collimation spatter method on this titanium silicide, and the heat titanium nitride layer formed on this titanium nitride layer While being formed on the front face of the barrier layer which it had, and a layer insulation layer, the 2nd conductor electrically connected to the contact field of the 1st conductor through the barrier layer is prepared.
[0037] The semiconductor device concerning invention of the 2nd of this invention The layer insulation layer by which it was formed on the 1st conductor which has a contact field on a front face, and this 1st conductor, and 2.5 or more contact holes were formed for the aspect ratio on the contact field of the 1st conductor, It is formed on the contact field of the 1st conductor located on the front face of this layer insulation layer, and in the contact hole of this layer insulation layer. It has the titanium layer which has a titanium silicide layer in the contact section with the contact field of the 1st conductor, the 1st [with the columnar crystal formed on this titanium layer] titanium nitride layer, and the 2nd [with the granular crystal formed on this 1st titanium nitride layer] titanium nitride layer. The thickness on the front face of a layer insulation layer of a titanium layer is 150-500A while the thickness of the titanium silicide layer on the contact field of the 1st conductor is 50-200A. Each thickness on the front face of a layer insulation layer of the 1st and 2nd titanium nitride layers is 100A or more. And the barrier layer

whose thickness of the sum total on the front face of a layer insulation layer is 400-1000A while the thickness of the sum total on the contact field of the 1st conductor is 60-300A, It is formed on a barrier layer and the 2nd conductor electrically connected to the contact field of the 1st conductor through the barrier layer is prepared.

[0038] The manufacture approach of the semiconductor device concerning invention of the 3rd of this invention The process which forms the layer insulation layer in which a contact hole is formed on the contact field of this 1st conductor on the 1st conductor which has a contact field on a front face, The process which forms the 1st titanium layer by the collimation spatter method on the contact field of the 1st conductor located on the front face of this layer insulation layer, and in the contact hole of this layer insulation layer, The process which forms a titanium nitride layer by the collimation spatter method on this 1st titanium layer, The process which forms the 2nd titanium layer by the collimation spatter method on this titanium nitride layer, While heat-treating in nitriding nature ambient atmospheres, such as nitrogen or an ammonia ambient atmosphere, and using the contact section with the contact field of the 1st conductor in the 1st titanium layer as a titanium silicide layer The process which uses the 2nd titanium layer as a heat titanium nitride layer, and the process which forms the 2nd conductor connected to this heat titanium nitride layer and an electric target on a heat titanium nitride layer are established.

[0039]

[Function] If it is in invention of the 1st of this invention, the titanium silicide layer of a barrier layer makes the electrical installation of the 1st conductor and the 2nd conductor perform by low resistance. By time amount with the titanium nitride layer which constitutes a barrier layer and which was formed by the collimation spatter method and a heat titanium nitride layer short on the contact field of the 1st conductor located in the contact hole of a layer insulation layer Generating of particle is controlled, and thickness is formed thickly and prevents the diffusion to the 1st conductor from the 2nd conductor.

[0040] If it is in invention of the 2nd of this invention, the 1st [with a columnar crystal] titanium nitride layer and the 2nd [with a granular crystal] titanium nitride layer from which the titanium silicide layer of the titanium layer of a barrier layer makes the electrical installation of the 1st conductor and the 2nd conductor perform by low resistance, and constitutes a barrier layer prevent the diffusion to the 1st conductor from the 2nd conductor.

[0041] If it is in invention of the 3rd of this invention, by the collimation spatter method The 1st titanium layer, A titanium nitride layer and the 2nd titanium layer can be formed on the contact field of the 1st conductor which makes bottom product coverage high and is located in the contact hole of a layer insulation layer in it. Formation of the 2nd titanium layer heightens the throughput of collimation spatter equipment. Generating of particle is controlled, and the titanium silicide layer of the 1st titanium layer makes the electrical installation of the 1st conductor and the 2nd conductor perform by low resistance, and prevents the diffusion to the 1st conductor from a titanium nitride layer and the heat titanium nitride layer from the 2nd titanium layer, and the 2nd conductor.

[0042]

[Example]

Example 1. drawing 1 thru/or drawing 8 show the example 1 of this invention. In drawing 1 , 1 is the semi-conductor substrate which consists of a silicon substrate used as the 1st conductor, and the semi-conductor substrate of P type is used in this example 1. It is the impurity diffusion field formed in the front face of this semi-conductor substrate, and 2 has contact field 2a in a part, and is the source / drain field of one N type of an MOS transistor in this example 1. 3 was the layer insulation layer by which it was formed on the front face of the above-mentioned semi-conductor substrate 1, and the contact hole 4 was formed on contact field 2a of the above-mentioned semi-conductor substrate 1, in this example 1, the aspect ratio of a contact hole 4 is 2.5 (when it says for the diameter of a contact hole 4, it is 0.6 micrometers or less) or more, and the aspect ratio whose diameter is 0.5 micrometers and whose depth is 1.5 micrometers as a concrete example made it the thing of 3.

[0043] 5 is formed on contact field 2a of the above-mentioned semi-conductor substrate 1 located on the front face of this layer insulation layer, and in the contact hole 4 of this layer insulation layer. In the titanium layer which has the titanium silicide layer 7 in the contact section with contact field 2a of the

above-mentioned semi-conductor substrate 1, in this example 1 The thickness on the front face of the layer insulation layer 3, i.e., a flat part, shall be about 200A as the concrete example, and the thickness of the titanium silicide layer 7 shall be about 75A.
[0044] 6 is the 1st titanium nitride layer formed by the collimation spatter method on the front face of the titanium layer 6 containing this titanium silicide layer 7. As shown in drawing 2 , it shall have a columnar crystal with a 200-300A diameter, and in this example 1, the thickness on the front face of the layer insulation layer 3, i.e., a flat part, shall be about 500A as that concrete example, and the thickness on contact field 2a of the semi-conductor substrate 1 shall be about 75A.
[0045] 12 is the 2nd titanium nitride layer which consists of a heat titanium nitride layer formed on the front face of this 1st titanium nitride layer 6. As shown in drawing 3 , it shall have a granular crystal with a 100-200A diameter, and in this example 1, the thickness on the front face of the layer insulation layer 3, i.e., a flat part, shall be about 200A as that concrete example, and the thickness on contact field 2a of the semi-conductor substrate 1 shall be about 30A. In addition, the barrier layer is formed by the titanium layer 6 containing the above-mentioned titanium silicide layer 7, the 1st titanium nitride layer 6, and the 2nd titanium nitride layer 12.
[0046] 9 is the embedding part which is embedded in the contact hole 4 of the above-mentioned layer insulation layer 3, is connected to a barrier layer and an electric target, and is electrically connected with the impurity diffusion field 2 of the above-mentioned semi-conductor substrate 1, and is formed with the tungsten in this example 1. 10 is the wiring section formed on the barrier layer on the above-mentioned layer insulation layer 3, constitutes the 2nd conductor which serves as a wiring layer by the above-mentioned embedding part 9, and is formed in this example 1 with aluminum alloys, such as aluminum, aluminum-0.5wt%Cu, or aluminum-1wt%Si-0.5wt%Cu, while connecting with this embedding part 9 electrically.
[0047] Next, the manufacture approach of the semi-conductor layer constituted in this way is explained according to drawing 4 thru/or drawing 7 . First, as shown in drawing 4 , the layer insulation layer 3 is formed on the front face of the semi-conductor substrate 1 with which the impurity diffusion field 2 where a part becomes contact field 2a was formed in the front face, and a contact hole 4 is formed so that contact field 2a may be exposed in this layer insulation layer 3.
[0048] Next, as shown in drawing 5 , the collimation sputtering system equipped with the titanium target is used. The spatter of titanium is performed in an argon gas ambient atmosphere on contact field 2a of the semi-conductor substrate 1 located on the front face of the layer insulation layer 3, and in the contact hole 4 of this layer insulation layer 3. The 1st titanium layer 5 The spatter (reactant spatter) of titanium is performed on this 1st titanium layer 5 in the nitriding nature ambient atmospheres in nitrogen-gas-atmosphere mind or the mixed-gas ambient atmosphere of nitrogen and an argon etc. the titanium nitride layer 6 On this titanium nitride layer 6, the spatter of titanium is performed in an argon gas ambient atmosphere, and sequential formation of the 2nd titanium layer 13 is carried out.
[0049] A concrete example of formation of the titanium layer 5 of these 1st, the titanium nitride layer 6, and the 2nd titanium nitride layer 13 is explained according to drawing 8 . The aspect ratio whose depth the diameter of a contact hole 4 is 0.5 micrometers, and is 1.5 micrometers specifically sets to the thing of 3. The 1st titanium layer 5 whose thickness is about 200A, the titanium nitride layer 6 whose thickness is about 500A, and the 2nd titanium layer whose thickness is about 200A on the front face of the layer insulation layer 3, i.e., a flat part The aspect ratio of a collimator 105 forms using the thing (for the diameter of a hole, the height of 2cm and a hole is 3cm) of 1.0 using the collimation spatter equipment (however, a shutter 109 is nothing) shown in drawing 16 .
[0050] First, the wafer 102 containing the semiconductor device formed to the condition shown in drawing 4 is laid on the front face of the heating stage 101, and even a wafer is fixed in 103. A wafer 102 is heated by the heating stage 102. Moreover, vacuum suction of the body of equipment 101 interior is carried out. In this condition, argon gas is introduced in the body 101 of equipment, and the body of equipment 101 interior is made into an argon gas ambient atmosphere. And power is supplied to the titanium target 104. In addition, time amount (argon gas installation period) after argon gas is introduced until power is supplied to the titanium target 104 is taken for 15 seconds as time amount until the flow

rate of the argon gas to the body of equipment 101 interior is stabilized, and the period and argon gas which power is supplied to the titanium target 104 and form the titanium layer 5 are continuing being introduced.

[0051] Then, the sputtered particles of titanium are emitted from the titanium target 104. With a collimator 105, many slanting components are removed and the emitted sputtered particles come flying on a wafer 102. The 1st titanium layer 5 will be formed on the front face of the layer insulation layer 3 on contact field 2a of the impurity diffusion field 2 in which the contact hole 4 of the layer insulation layer 3 is located, and the side face of the contact hole 4 of the layer insulation layer 3. When the formation period of this 1st titanium layer 5 was performed for 30 seconds, the 1st titanium layer 5 whose thickness is about 200A was obtained on the front face of the layer insulation layer 3, i.e., a flat part, and the 1st titanium layer 5 whose thickness is about 30A was obtained on contact field 2a of the impurity diffusion field 2 in which the contact hole 4 of the layer insulation layer 3 is located (bottom product coverage is about 15%).

[0052] Next, in the condition of having described above, the power of the titanium target 104 is turned off, nitrogen gas is introduced in the body 101 of equipment at installation and coincidence of argon gas, and the body of equipment 101 interior is made into the mixed-gas ambient atmosphere of argon gas and nitrogen gas. And power is supplied to the titanium target 104. In addition, time amount (nitrogen gas installation period) after nitrogen gas is introduced until power is supplied to the titanium target 104 is taken for 15 seconds as time amount until the flow rate of the nitrogen gas to the body of equipment 101 interior is stabilized, and the period and argon gas which power is supplied to the titanium target 104 and form the titanium nitride layer 6, and nitrogen gas are continuing being introduced.

[0053] Then, the sputtered particles of titanium are emitted, and it reacts with the nitrogen in a mixed-gas ambient atmosphere, and becomes the sputtered particles of titanium nitride from the titanium target 104. As for these sputtered particles, many slanting components will be removed by the collimator 105, it will come flying on a wafer 102, and the titanium nitride layer 5 will be formed on the whole surface surface of the titanium layer 5. When the formation period of this titanium nitride layer 5 was performed for 75 seconds, the titanium nitride layer 6 whose thickness is about 500A was obtained on the front face of the layer insulation layer 3, i.e., a flat part, and the titanium layer 5 whose thickness is about 75A was obtained on contact field 2a of the impurity diffusion field 2 in which the contact hole 4 of the layer insulation layer 3 is located (bottom product coverage is about 15%).

[0054] Next, supplying the power of the titanium target 105 is continued in the condition of having described above, and installation of nitrogen gas is suspended. Then, the sputtered particles of titanium are emitted from the titanium target 104, continuously, as for the emitted sputtered particles, many slanting components will be removed by the collimator 105, it will come flying on a wafer 102, and the 2nd titanium layer 13 will be formed on the whole surface surface of the titanium nitride layer 6. When the formation period of this 2nd titanium layer 13 was performed for 30 seconds, the 2nd titanium layer 13 whose thickness is about 200A was obtained on the front face of the layer insulation layer 3, i.e., a flat part, and the 2nd titanium layer 13 whose thickness is about 30A was obtained on contact field 2a of the impurity diffusion field 2 in which the contact hole 4 of the layer insulation layer 3 is located (bottom product coverage is about 15%).

[0055] In this 2nd titanium layer 13 formation period, since the sputtered particles of the titanium from the titanium target 104 adhere also to a collimator 105, exfoliation of the titanium nitride to which titanium acted on as a paste and the collimator 105 adhered is controlled, and moreover, titanium covers the titanium nitride to which the collimator 105 adhered, and it adheres to it. Titanium acted as a paste in 30 seconds, and this 2nd titanium layer 13 formation period was enough for that of a wrap in titanium nitride. In addition, although formation of this 2nd titanium layer 13 is continuously performed with formation of the titanium nitride layer 6 and the condition that nitrogen gas is introduced a little in the formation early stages of the 2nd titanium layer 13 arises, since this 2nd titanium layer 13 is used as a heat titanium nitride layer by the next process, it is satisfactory at all.

[0056] Then, the power of the titanium target 104 is turned off, installation of argon gas is suspended (it required for 10 seconds as this period), and a series of processings of formation of the 1st titanium layer

5, the titanium nitride layer 6, and the 2nd titanium layer 13 are ended.
[0057] Next, as the wafer 102 with which the 1st titanium layer 5, the titanium nitride layer 6, and the 2nd titanium layer 13 were formed is conveyed in a vacuum to the heat chamber (not shown) in collimation spatter equipment and it is shown in drawing 6 In the heat chamber in nitriding nature ambient atmospheres, such as nitrogen or an ammonia ambient atmosphere, about 600-800 degrees C, For example, while heat-treating for 30 seconds at 650 degrees C and using the contact section with contact field 2a of the semi-conductor substrate 1 in the 1st titanium layer 5 as the titanium silicide layer 7, let the 2nd titanium layer 13 be the heat titanium nitride layer 12. In addition, although the above-mentioned example showed what heat-treated in the heat chamber in collimation spatter equipment, it may heat-treat collimation spatter equipment with another thermal treatment equipment. In this case, what is necessary is just to heat-treat for 30 seconds at 750 degrees C in nitriding nature ambient atmospheres, such as nitrogen or an ammonia ambient atmosphere.
[0058] All the titanium layers of the contact section with contact field 2a in the titanium layer 5 were silicide-ized, and the titanium silicide layer 7 formed at this time has entered the interior of the impurity diffusion field 2 somewhat. moreover, the heat titanium nitride layer 12 -- the 2nd titanium layer 13 -- all are changing. Thus, the thing of the three-tiered structure which consists of the titanium layer 5 and the titanium nitride layer 6 which were formed, and which have the titanium silicide layer 7, and a heat titanium nitride layer 13 becomes a barrier metal layer eventually.
[0059] Next, all over the whole front-face top surface of the semi-conductor substrate 1, i.e., the front face of the heat titanium nitride layer 12, as shown in drawing 7 , the tungsten layer 8 is formed with the blanket CVD method which used WF6 gas. Etchback of the whole surface of this tungsten layer 8 is carried out, only in contact field 2a, it leaves a tungsten layer and the tungsten plug 9 is formed. And as shown in drawing 1 , an aluminum layer is formed in the whole front-face top surface of the semi-conductor substrate 1, i.e., the whole surface surface of the exposed heat titanium nitride layer 12, and the front face of the tungsten plug 9, this aluminum layer is etched with the usual photoengraving-process technique, and the wiring section 10 is formed.
[0060] At this time, the titanium layer 5 and the titanium nitride layer 6 which are located under an aluminum layer, and the heat titanium nitride layer 12 are also etched and removed except for the part located under the wiring section 10. In addition, the wiring section 10 constitutes the wiring layer by the tungsten plug 9. Thus, the wiring layer which consists of the impurity diffusion field 2, the wiring section 10, and the tungsten plug 9 which were formed in the front face of the semi-conductor substrate 1 will be electrically connected through the barrier metal layer which consists of the titanium silicide layer 7, a titanium nitride layer 6, and a heat titanium nitride layer 12.
[0061] thus -- since the titanium layer 5 which has the titanium silicide layer 7 returns the natural-oxidation film which exists on contact field 2a on the occasion of heat treatment of the titanium layer 5 since titanium is activity, and reacts with the silicon of the impurity-diffusion field 2 in the constituted semiconductor device and the titanium silicide layer 7 is formed -- low [of the impurity-diffusion field 2 and a wiring layer] -- the role which realizes electrical installation [****] has played.
[0062] The thickness on the front face of the layer insulation layer 3, i.e., a flat part, the 1st titanium layer 5 specifically About 200A, The thickness on contact field 2a of the impurity diffusion field 2 in which the contact hole 4 of the layer insulation layer 3 is located is about 30A. The titanium silicide layer 7 on contact field 2a formed of heat treatment became about 75A which is about 2.5 times in case the thickness is a titanium layer, and had fully realized electrical installation of the impurity diffusion field 2 and a wiring layer by low resistance.
[0063] Since film exfoliation is produced, or WF6 and the titanium layer 5 which are material gas for forming the tungsten layer 8 will react and formation of the tungsten layer 8 will become difficult if it forms in the front face of the direct titanium layer 5 in case the tungsten plug 9 which constitutes a wiring layer is formed, the titanium nitride layer 6 and the heat titanium nitride layer 12 function as adhesion layers of the titanium layer 5 and the tungsten layer 8. Moreover, in case these titanium nitride layer 6 and the heat titanium nitride layer 12 form the tungsten layer 8 with the blanket CVD method which used WF6 gas, they have played the role which prevents that a wormhole occurs to the impurity

diffusion field 2.
[0064] Furthermore, in order to form by the spatter in the nitriding nature ambient atmosphere of 4mTorr extent where it is to some extent high in order to fully nitride the titanium nitride layer formed of a reactant spatter, As opposed to dispersion by the controlled atmosphere of sputtered particles becoming large, and a slanting component increasing somewhat Since the heat titanium nitride layer 12 is formed by heat-treating the titanium layer 13 and the titanium layer 13 can be formed by the spatter in the argon gas ambient atmosphere of 1mTorr extent, There are few slanting components based on dispersion by the controlled atmosphere, and bottom product coverage is good to the titanium nitride layer formed of a reactant spatter.
[0065] Moreover, since the heat titanium nitride layer 12 is not a columnar crystal but a granular crystal, in case it forms the tungsten layer 8 with the blanket CVD method using WF6 gas unlike the titanium nitride layer formed of a reactant spatter, its operation which prevents that a wormhole occurs to the impurity diffusion field 2 to the titanium nitride layer which WF6 gas cannot invade easily and is formed of a reactant spatter is strong.
[0066] The thickness on the front face of the layer insulation layer 3, i.e., a flat part, the titanium nitride layer 6 specifically About 500A, Since the thickness on contact field 2a of the impurity diffusion field 2 in which the contact hole 4 of the layer insulation layer 3 is located is about 75A and the heat titanium nitride layer 12 serves as the almost same thickness as the 2nd titanium layer 13 by heat treatment, The thickness on contact field 2a of the impurity diffusion field 2 in which the contact hole 4 of about 200A and the layer insulation layer 3 is located by the thickness on the front face of the layer insulation layer 3, i.e., a flat part, is about 30A. The thickness of the sum total of the titanium nitride layer 6 and the heat titanium nitride layer 12 on contact field 2a of the impurity diffusion field 2 in which the contact hole 4 of the layer insulation layer 3 is located became about 105A, and prevention of sufficient wormhole was able to be aimed at.
[0067] After forming the titanium layer 5, the titanium nitride layer 6, and the 2nd titanium layer 13, when it forms on the other hand to the condition shown in drawing 1 , by the approach shown in drawing 8 about 650 wafers 102 The titanium silicide layer 7 formed of heat treatment The role which realizes electrical installation [****] is played. that the thickness of whose is about 75A obtains -- having -- low [of the impurity diffusion field 2 and a wiring layer] -- Moreover, the titanium nitride layer 6 and the heat titanium nitride layer 12 prevent the film exfoliation at the time of forming the tungsten plug 9 which constitutes a wiring layer, and function as adhesion layers of the titanium layer 5 and the tungsten layer 8. The thickness of the sum total on contact field 2a of the impurity diffusion field 2 in which the contact hole 4 of the layer insulation layer 3 is located about 105A A ****, When forming the tungsten layer 8 with the blanket CVD method using WF6 gas, the role which prevents that a wormhole occurs to the impurity diffusion field 2 was played.
[0068] Furthermore, the titanium layer 5, the titanium nitride layer 6, and the 2nd titanium layer 13 are formed by the approach shown in drawing 8 . By the approach shown in the thing (it is hereafter called for short the thing of a three-layer barrier layer) in which the barrier metal layer which consists of the titanium layer 5, a titanium nitride layer 6, and a heat titanium nitride layer 12 by heat-treating was formed, and drawing 18 When the thing (it is hereafter called for short the thing of a two-layer barrier layer) in which the barrier metal layer which consists of a titanium layer 5 and titanium nitride 6 was formed is compared, the thing of a three-layer barrier layer has the further following advantages to the thing of a two-layer barrier layer.
[0069] To the 1st, the thing of a three-layer barrier layer can be shortened by the processing time of one wafer 102 20% to the thing of a two-layer barrier layer, and it leads to improvement in the throughput of collimation spatter equipment. That is, as for the thing of a two-layer barrier layer, to a series of processing times which process one wafer 102 taking 220 seconds, a series of processing times of the thing of a three-layer barrier layer which process one wafer 102 are good in 175 seconds, and it can aim at compaction for 45 seconds so that clearly from drawing 8 , so that clearly from drawing 18 .
[0070] To the 2nd, the thing of a three-layer barrier layer can reduce [the consumption of a titanium target] 18% to the thing of a two-layer barrier layer. That is, the thing of a two-layer barrier layer

receives, although the time amount which supplies power among a series of processings in which one wafer 102 is processed at the titanium target 104 is 165 seconds so that clearly from drawing 18 . The thing of a three-layer barrier layer has the good time amount which supplies power to the titanium target 104 among a series of processings in which one wafer 102 is processed in 135 seconds, and can aim at compaction for 30 seconds, and its consumption of the part titanium target 104 decreases so that clearly from drawing 8 .

[0071] When the thing of a three-layer barrier layer can reduce the consumption of a titanium target 18% to the thing of a two-layer barrier layer to the 3rd, the coating weight of the titanium nitride of the collimator 105 at the time of the thing of a three-layer barrier layer processing one wafer to the thing of a two-layer barrier layer etc. decreases, and the number of sheets of the wafer 102 which can be processed to exchange of a collimator 105 can be increased by 22%.

[0072] To the 4th, the thing of a three-layer barrier layer can suppress generating of particle low to the thing of a two-layer barrier layer. That is, the thing of a two-layer barrier layer receives the spatter of the titanium for forming the titanium nitride layer 6. As opposed to the rate of the spatter of the titanium for forming the titanium layer 5 and the spatter of the titanium of a cleaning period being 0.57 (= 400A / 700A) the thing of a three-layer barrier layer The rate of the spatter of the titanium for forming the 1st and 2nd titanium layers 5 and 13 to the spatter of the titanium for forming the titanium nitride layer 6 becomes large with 0.80 (= 400A / 500A). Consequently, since the thing of a three-layer barrier layer has the large rate which carries out the spatter of the titanium which functions as a paste which prevents exfoliation of the titanium nitride adhering to a collimator 105, the effectiveness of exfoliation prevention becomes large and it can suppress generating of particle low.

[0073] As stated above, what was shown in this example 1 has the effectiveness that low cost-ization by improvement in the throughput which could prevent certainly generating of the wormhole to the impurity diffusion field 2, and includes the exchange stage of the collimator 105 of collimation spatter equipment, the cutback of the consumption of a titanium target, and the reduction in particle can be attained while fully being able to realize electrical installation of the impurity diffusion field 2 and a wiring layer by low resistance.

[0074] Furthermore, based on a concrete example shown above, the aspect ratio whose diameter is 0.5 micrometers and whose depth is 1.5 micrometers as a contact hole 4 of the layer insulation layer 3 sets an artificer etc. to the thing of 3. The aspect ratio of the collimator 105 shown in drawing 16 is the thing (the diameter of a hole 2cm) of 1.0. The collimation [height / of a hole] spatter equipment using 3cm The sequence which used (however, a shutter 109 is nothing) and was shown in drawing 8 It was based on (however, the processing times for formation of the titanium layer 5, the titanium nitride layer 6, and the 2nd titanium layer 13 differ), and the following was found when the semiconductor device with which the titanium layer 5, the titanium nitride layer 6, and the 2nd titanium layer 13 which have various thickness were formed was manufactured.

[0075] That is, the thickness of the titanium layer 5 on the front face of the layer insulation layer 3 of the titanium layer 5 needs to be 150-500A (about bottom product coverage 15%) while the thickness of the titanium silicide layer 7 on contact field 2a is 50-200A. That is, if the electrical installation of the impurity diffusion field 2 and a wiring layer will become high resistance, good contact resistance will no longer be obtained, if the thickness of the titanium silicide layer 7 becomes less than 50A, and the thickness of a titanium silicide layer exceeds 200A A possibility of the reaction of titanium and the impurity diffusion field 2 increasing too much, and there being a possibility that the titanium silicide layer 7 may be formed exceeding the depth of the impurity diffusion field 2, and causing junction leak is high.

[0076] Moreover, the thickness of the sum total on the front face of the layer insulation layer 3 of the titanium nitride layer 6 and the heat titanium nitride layer 12 needs to be 400-1000A (about bottom product coverage 15%) while each thickness on the front face of the layer insulation layer 3 is 100A or more and the thickness of the sum total on contact field 2a is 60-300A. That is, when the prevention effectiveness of the wormhole by the tungsten which constitutes the embedding part 9 of a wiring layer as the thickness of the sum total of the titanium nitride layer 6 on contact field 2a and the heat titanium

nitride layer 12 is less than 60A was low and exceeded 300A, it was that in which the throughput of collimation spatter equipment etc. deteriorates.

[0077] In addition, in the above-mentioned example 1, although what formed the embedding part 9 and the wiring section 10 of a wiring layer with the CVD method, respectively was shown, it is not limited to a CVD method and you may form using other film formation approaches, such as PVD. Moreover, although what used the 1st conductor as the semi-conductor substrate 1, and used the 2nd conductor as the wiring layer in the above-mentioned example 1 was shown What is not restricted to this, used as the lower layer wiring layer which consists of polish recon arranged as the 1st conductor at the lower layer, and was used as the upper wiring layer with the same gestalt as the 2nd conductor of an example 1 formed through the layer insulation layer on the lower layer wiring layer in the 2nd conductor may be used.

[0078] Example 2. drawing 7 shows the example 2 of this invention, and forms the wiring layer which constitutes the 2nd conductor from a tungsten simple substance to what constituted the wiring layer from which the thing of the above-mentioned example 1 constitutes the 2nd conductor by the embedding part which consists of the wiring section which consists of aluminum or an aluminum alloy, and a tungsten. It is the same configuration as the example 1 described above about other points.

[0079] That is, the semiconductor device shown in this example 2 is formed like the example 1 which the configuration shown in drawing 7 described above. Then, although etchback of the whole surface of the tungsten layer 8 formed by the blanket CVD method using WF6 gas was carried out, it left the tungsten layer only in contact field 2a and the tungsten plug 9 was formed if it was in the thing of an example 1 In this example 2, the tungsten layer 8 formed by the blanket CVD method using WF6 gas is etched with a photoengraving-process technique by the pattern of a wiring layer, and an embedding part and the wiring layer 14 with wiring **** are formed. At this time, the titanium layer 5 and the titanium nitride layer 6 which are located under a tungsten layer, and the heat titanium nitride layer 12 are also etched and removed except for the part located under a wiring layer 14.

[0080] Thus, if it is in the constituted semiconductor device, the same effectiveness as the above-mentioned example 1 is done so. In addition, although what constituted with the tungsten the wiring layer 14 which constitutes the 2nd conductor in this example 1 was shown Not the thing restricted to a tungsten but copper (Cu), titanium nitride (TiN), Aluminum (aluminum), titanium silicide (TiSi2), tungsten silicide (WSi2), or polish recon may constitute a wiring layer 14. Moreover, two-layer and the three-tiered structure which were chosen from from among these ingredients may constitute a wiring layer 14. In this case, the barrier layer constituted by the titanium layer 6 and the titanium nitride layer 6 containing the titanium silicide layer 7, and the heat titanium nitride layer 12 has the work which prevents the reaction of a wiring layer 14 and the silicon of the semi-conductor substrate 1, and does so the same effectiveness as the above-mentioned example 2.

[0081] The example of application at the time of applying the example of application next the above-mentioned example 1, or an example 2 to dynamic random access memory is explained using drawing 10 . Drawing 10 is the sectional view showing the body of dynamic random access memory, and does not show the barrier layer constituted by the titanium layer 6 and the titanium nitride layer 6 which contained the titanium silicide layer 7 in the above-mentioned examples 1 and 2 on account of explanation, and the heat titanium nitride layer 12.

[0082] The semi-conductor substrate with which 200 consists of silicon in drawing 10 , and 201 and 202 were formed in the front face of this semi-conductor substrate 200. The source / drain field of a couple which consists of an impurity diffusion field of the N type which constitutes the transistor of a memory cell, 203 is the gate electrode which was formed through gate oxide on the front face of the above-mentioned semi-conductor substrate 200 between the source / drain field of these couples and which constitutes the transistor of a memory cell, is formed in polish recon and constituted by a part of word line of a response. 204 thru/or a layer insulation layer [in / in respectively 211 / each class], and 212 are the bit lines electrically connected to one source / drain field 202 of the transistor of the above-mentioned memory cell through the contact hole of the layer insulation layer 204, and the lower layer is constituted for tungsten silicide and the upper layer by the two-layer structure which consists of polish

recon.
[0083] 213 is the storage node which constitutes one electrode of the capacitor of the above-mentioned memory cell which is formed in the upper layer from this bit line, and is electrically connected to the source / drain field 201 of another side of the transistor of the above-mentioned memory cell through the contact hole of the layer insulation layers 204 and 205, and is constituted by polish recon. 215 is the cel plate by which opposite arrangement was carried out through this storage node and dielectric film 214 and which constitutes one electrode of the capacitor of the above-mentioned memory cell, and is constituted by polish recon. It is the 1st aluminum layer which consists of the aluminum or the aluminum alloy prepared on this cel plate, and if 216 is one of those which have been arranged at the memory cell section, opposite arrangement is carried out, for example with a word line, and in order to attain low resistance-ization of a word line, it constitutes the wiring layer connected to the word line and the electric target in two or more places (piling). 217 is the 2nd aluminum layer prepared in the upper layer of this 1st aluminum layer, and if it is in some which have been arranged at the memory cell section, it constitutes the wiring layer connected to the bit line and the electric target, for example.
[0084] 218 and 219 are the gate electrodes with which the source / drain field of a couple which consists of an impurity diffusion field of the N type which constitutes the n channel transistor of the circumference circuit formed in the front face of the above-mentioned semi-conductor substrate 200, and 220 constitute the n channel transistor of the circumference circuit formed through gate oxide on the front face of the above-mentioned semi-conductor substrate 200 between the source / drain field of these couples, and it is formed in polish recon. 221 and 222 are the gate electrodes with which the source / drain field of a couple which consists of an impurity diffusion field of the P type which constitutes the p channel transistor of the circumference circuit formed in the front face of the above-mentioned semi-conductor substrate 200, and 223 constitute the p channel transistor of the circumference circuit formed through gate oxide on the front face of the above-mentioned semi-conductor substrate 200 between the source / drain field of these couples, and it is formed in polish recon.
[0085] 224 is the embedding part of the wiring layer which consists of a tungsten embedded in the contact hole of the layer insulation layers 208, 209, and 210 formed in the location of the source / drain fields 218 and 219 of the n channel transistor of a circumference circuit, and the source / drain fields 221 and 222 of a p channel transistor, respectively, and forms the wiring layer which constitutes the 2nd conductor by the 1st aluminum layer used as the wiring section connected electrically.
[0086] Next, in the dynamic random access memory constituted in this way, the contact section of the 1st conductor and the 2nd conductor with which the barrier layer constituted by the titanium layer 6 and the titanium nitride layer 6 containing the titanium silicide layer 7 in the above-mentioned examples 1 and 2, and the heat titanium nitride layer 12 is applied is explained.
[0087] (1) The 1st conductor is the semi-conductor substrate 200, the 2nd conductor is a bit line 212, and it is the contact section of one source / drain field 202 of the transistor of a memory cell, and a bit line 212.
(2) The 1st conductor is the semi-conductor substrate 200, the 2nd conductor is the storage node 213, and it is the contact section of the source / drain field 201 of another side of the transistor of a memory cell, and the storage node 213.
[0088] (3) the wiring layer which the 1st conductor is the semi-conductor substrate 200, and the 2nd conductor becomes from the 1st aluminum layer 216 electrically connected to an embedding part 224 and this embedding part 224 -- it is -- p of this wiring layer and a circumference circuit, or the contact section with the source / drain fields 218, 219, 221, and 222 of an n channel transistor.
(4) The 1st conductor is a bit line 212, the 2nd conductor is the 2nd aluminum layer 217, and it is the contact section of a bit line 212 and the 2nd aluminum layer 217.
[0089] In the dynamic random access memory by which the bit line 212 was formed in the lower layer of the storage node 213, and the 1st aluminum layer was especially formed in the upper layer of the cel plate 215 p of a wiring layer and a circumference circuit which has the 1st aluminum layer 216 of a circumference circuit, or the electrical installation with the source / drain fields 218, 219, 221, and 222 of an n channel transistor Since it is carried out through the contact hole of the layer insulation layers

208, 209, and 210, the depth of this contact hole is deep, and since the aspect ratio is very high, when the above-mentioned example is applied, it has extraordinary effectiveness.

[0090]

[Effect of the Invention] The 1st conductor with which invention of the 1st of this invention has a contact field on a front face, The layer insulation layer by which it was formed on this 1st conductor and the contact hole was formed on the contact field of the 1st conductor, The titanium silicide layer formed on the contact field of the 1st conductor located in the contact hole of this layer insulation layer, the titanium nitride layer formed by the collimation spatter method on this titanium silicide, and the heat titanium nitride layer formed on this titanium nitride layer Since the 2nd conductor electrically connected to the contact field of the 1st conductor through the barrier layer should be prepared while being formed on the front face of the barrier layer which it had, and a layer insulation layer Moreover, the titanium nitride layer and heat titanium nitride layer which electrical installation can perform the 1st conductor and 2nd conductor by low resistance, and constitute a barrier layer for a short time Generating of particle is controlled, thickness is thickened, and can be formed and it has the effectiveness that the diffusion to the 1st conductor from the 2nd conductor can be prevented.

[0091] The 1st conductor with which invention of the 2nd of this invention has a contact field on a front face, The layer insulation layer by which it was formed on this 1st conductor and 2.5 or more contact holes were formed for the aspect ratio on the contact field of the 1st conductor, It is formed on the contact field of the 1st conductor located on the front face of this layer insulation layer, and in the contact hole of this layer insulation layer. It has the titanium layer which has a titanium silicide layer in the contact section with the contact field of the 1st conductor, the 1st [with the columnar crystal formed on this titanium layer] titanium nitride layer, and the 2nd [with the granular crystal formed on this 1st titanium nitride layer] titanium nitride layer. The thickness on the front face of a layer insulation layer of a titanium layer is 150-500A while the thickness of the titanium silicide layer on the contact field of the 1st conductor is 50-200A. Each thickness on the front face of a layer insulation layer of the 1st and 2nd titanium nitride layers is 100A or more. And the barrier layer whose thickness of the sum total on the front face of a layer insulation layer is 400-1000A while the thickness of the sum total on the contact field of the 1st conductor is 60-300A, Since the 2nd conductor which was formed on the barrier layer and was electrically connected to the contact field of the 1st conductor through the barrier layer should be prepared Electrical installation can perform the 1st conductor and 2nd conductor by low resistance, and it has the effectiveness that the 1st and 2nd titanium nitride layers which constitute a barrier layer can moreover prevent effectively the diffusion to the 1st conductor from the 2nd conductor.

[0092] The process at which invention of the 3rd of this invention forms the layer insulation layer in which a contact hole is formed on the contact field of this 1st conductor on the 1st conductor which has a contact field on a front face, The process which forms the 1st titanium layer by the collimation spatter method on the contact field of the 1st conductor located on the front face of this layer insulation layer, and in the contact hole of this layer insulation layer, The process which forms a titanium nitride layer by the collimation spatter method on this 1st titanium layer, The process which forms the 2nd titanium layer by the collimation spatter method on this titanium nitride layer, While heat-treating in nitriding nature ambient atmospheres, such as nitrogen or an ammonia ambient atmosphere, and using the contact section with the contact field of the 1st conductor in the 1st titanium layer as a titanium silicide layer Since the process which uses the 2nd titanium layer as a heat titanium nitride layer, and the process which forms the 2nd conductor connected to this heat titanium nitride layer and an electric target on a heat titanium nitride layer should be established Bottom product coverage is made high and the 1st titanium layer, a titanium nitride layer, and the 2nd titanium layer can be formed on the contact field of the 1st conductor. The formation process of the 2nd titanium heightens the throughput of collimation spatter equipment. Control generating of particle and the titanium silicide layer of the 1st titanium layer makes the electrical installation of the 1st conductor and the 2nd conductor perform to low resistance. It has the effectiveness that the heat titanium nitride layer from a titanium nitride layer and the 2nd titanium layer can prevent effectively the diffusion to the 1st conductor from the 2nd conductor.

[Translation done.]